Red and Bonita Mine

Removal Action – Bulkhead Plan Summary

May 2015

Mine Discharge and Underground Workings

- Flow is approximately 200 to 300 gpm
- Zinc concentration is consistently near 16,000 ug/L
- Cadmium concentrations are near 30 ug/L
- Iron concentration is approximately 93,000 ug/L
- pH ranges from 5.5 to 6 su.
- Underground workings are estimated at 3000 to 3500 ft.
- EPA and DRMS were able to access approximately 2000 ft in 2013

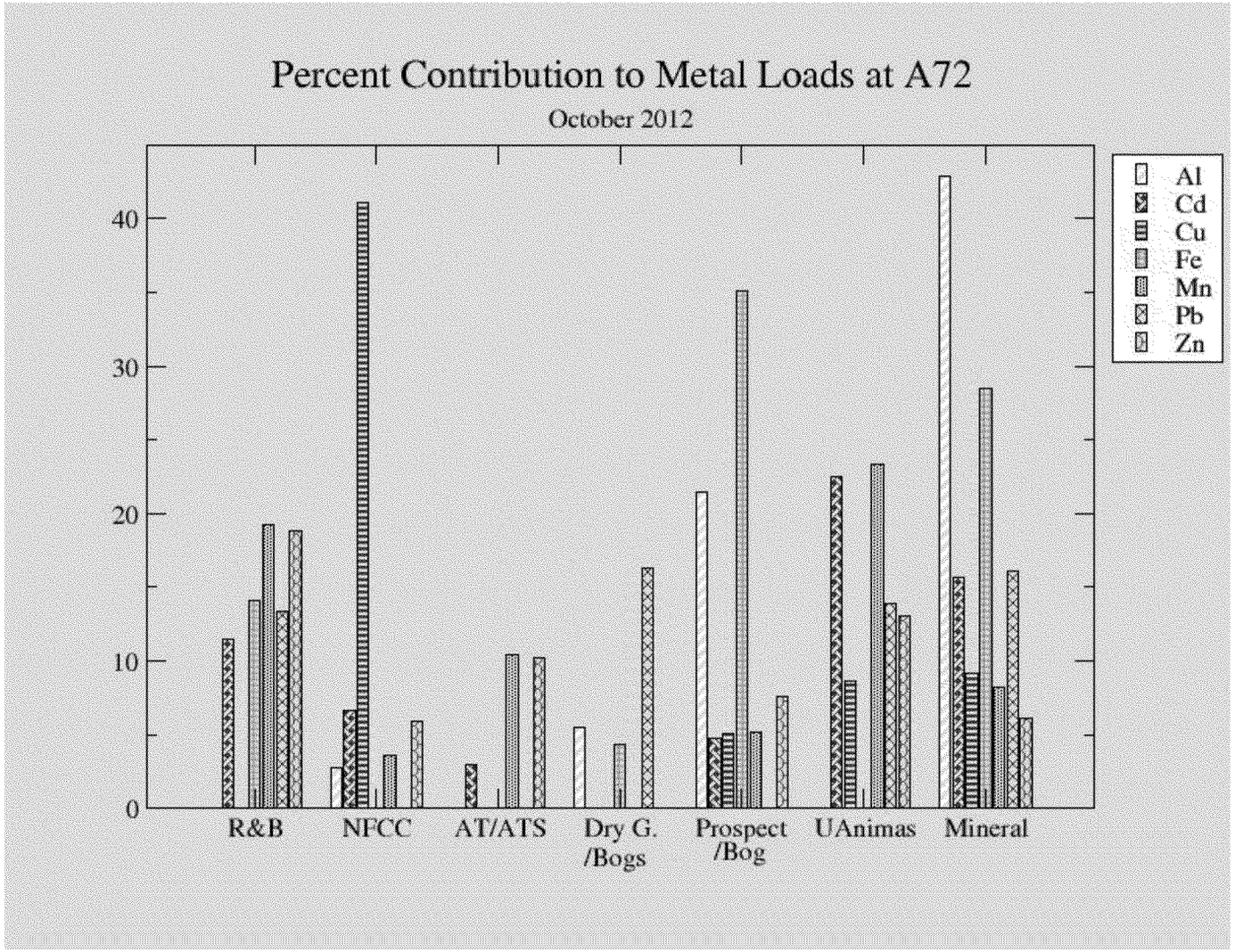
Adits Flows in Cement Ck from 2005 to 2012

Mine Adit Discharge 2005 to 2011

Mine	Elevation (feet AMSL)	Bulkhead Install	Flow Rate (gpm)						
			July 2005	September 2005	October 2006	Average 2010	Average 2011	July 2012	Oct 2012
Mogul (pH 3.5)	11,376	2003	21	27	11	54	56	128	90 (?)
Gold King 7 Level (pH 2.5 to 5)	11,386	None	42	135	314	206	140	128	55 – 85
Red & Bonita (pH 6)	**10,893**	**None**	**210**	**224**	**233**	**216**	**319**	314	**202**
American Tunnel (pH 5)	10,540	1997 2001 2002	95	90	84	101	101	193	103

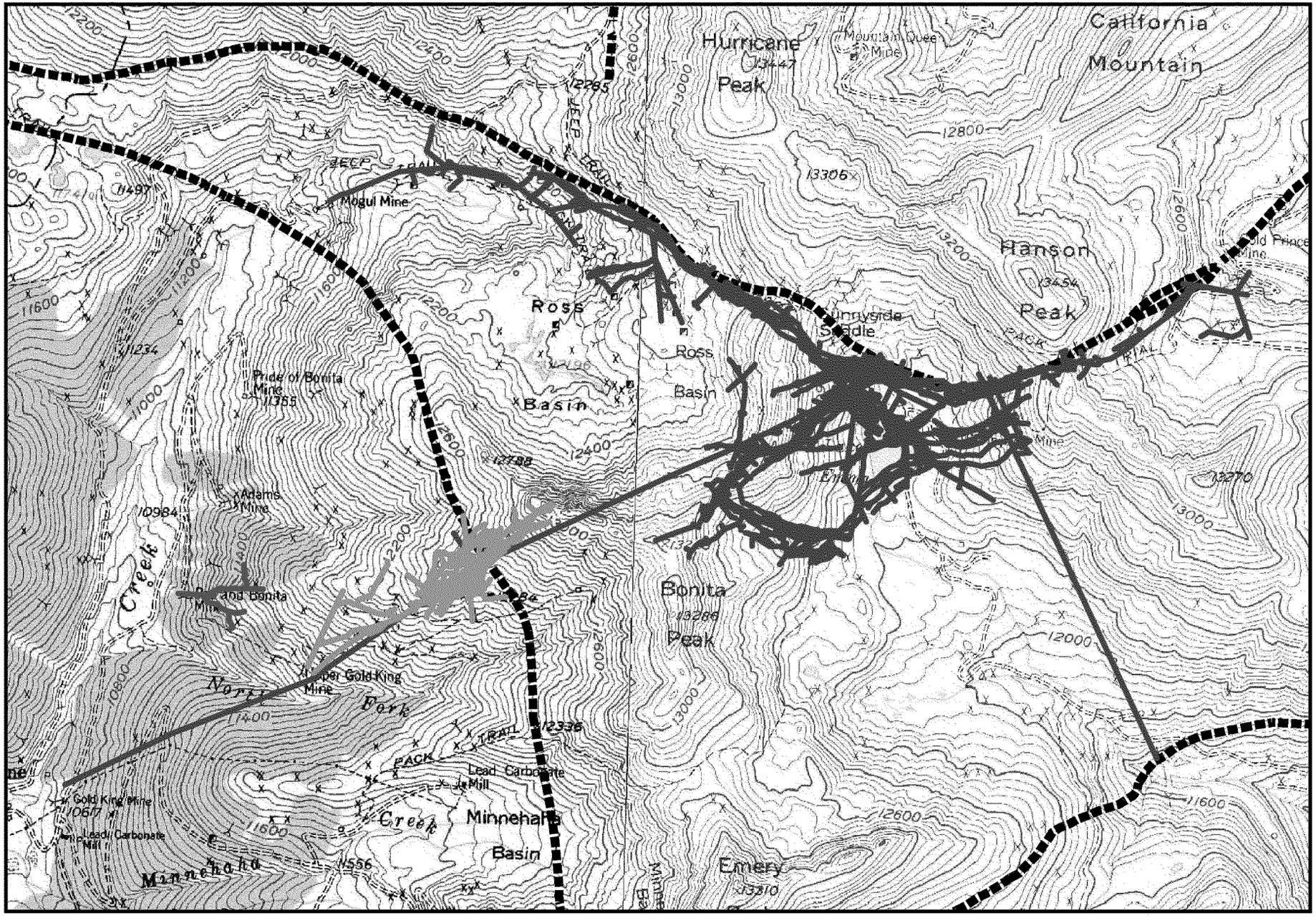
gpm = Gallons per minute.

USGS - Part IV: Results – Loads & Sources



Adit Loading Analysis Conclusion

- Red and Bonita contributes approximately 18% of the Zn and 12% of the Cd load in Oct 2012 in the Animas at A72 (relative source contributions vary seasonally)
- The flow from Red and Bonita averages approximately 300 gpm and appears to have stabilized since the Am Tnnl plugs
- Zn and Cd are two of the primary contaminants of concern based on the Screening Level Ecological Risk Assessment
- No other single mine source contributes as much Zn in either Cement Ck or the Animas
- USGS reactive / transport modeling indicates that the Zn from R n B adit is conserved in transport to A72



Prepared by Kirstin Brown, CDRMS, 1/21/2014

0 625 1,250 2,500 3,750 5,000 Feet

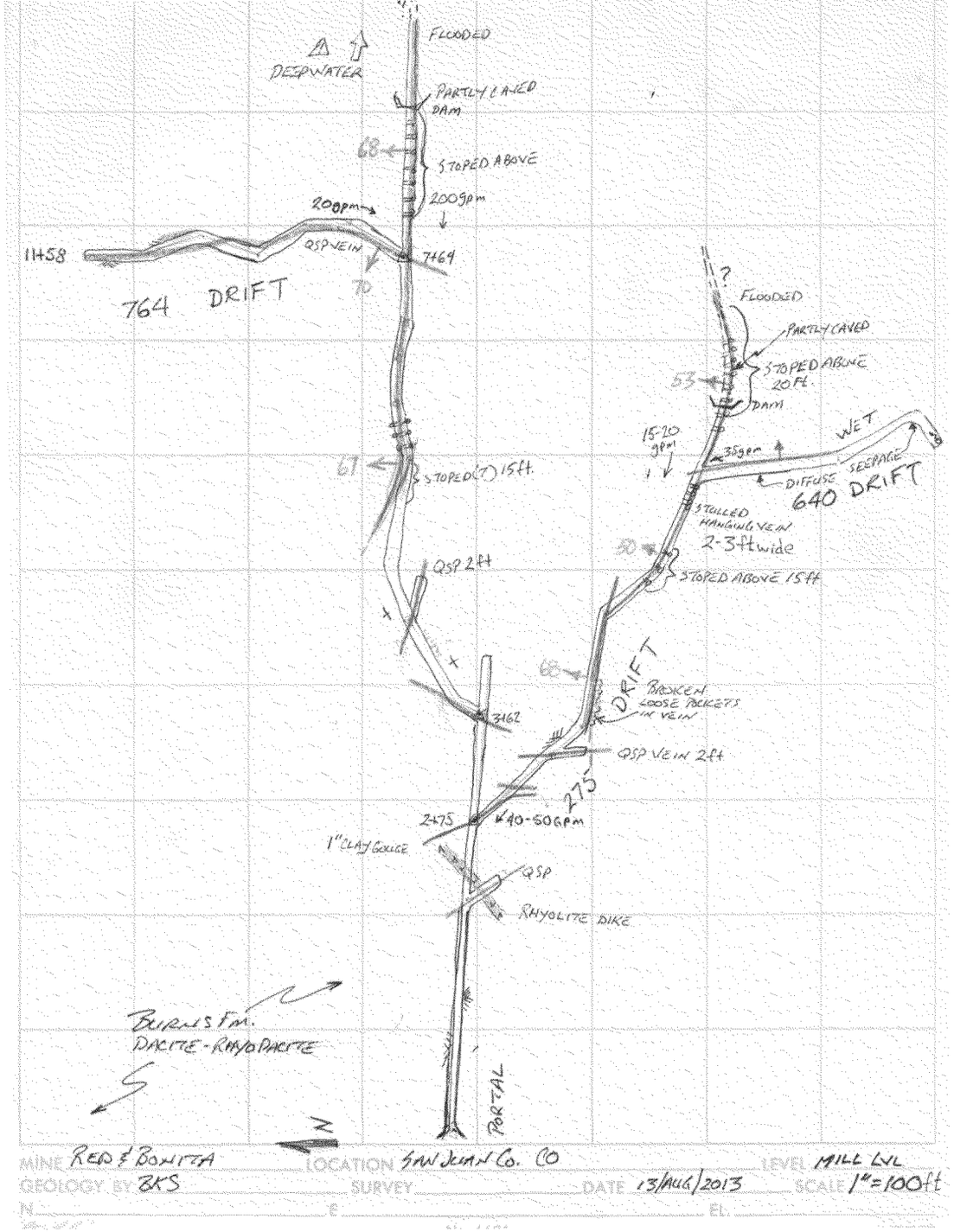
RED AND BONITA MAP
Mine Workings past cave-ins are only projected to line of sight
SUNNYSIDE WORKINGS
Most Recent workings, needs more work
GOLD KING WORKINGS
There is more data that needs to be added on 7 Level

Legend

- R & B Workings (Stover)
- GoldKing1thru7
- SunnysideWorkings
- USGS Mapped Faults PP 1651

N W E S

08/12/2013


FLOODED
DEEP WATER
PARTLY CAVED DAM
68
STOPED ABOVE
200gpm
200gpm
11458
QSP VEIN
7469
764 DRIFT
70
?
FLOODED
PARTLY CAVED
STOPED ABOVE 20 Ft.
53
DAM
15-20 gpm
35gpm
WET
DIFFUSE SEEPAGE
640 DRIFT
STOPED (?) 15ft.
67
STALLED HANGING VEIN 2-3ft wide
50
STOPED ABOVE 15ft
QSP 2ft
68
DRIFT
BROKEN LOOSE POCKETS IN VEIN
3162
QSP VEIN 2ft
275
2475
40-50GPM
1" CLAY GOUGE
QSP
RHYOLITE DIKE
BURNS Fm.
DACITE-RHYODACITE
S
N
PORTAL
MINE RED & BONITA
LOCATION SAN JUAN Co. CO
LEVEL MILL LVL
GEOLOGY BY BKS
SURVEY
DATE 13/AUG/2013
SCALE 1"=100ft
N
E
EL

Design Factors and Investigation Results

- Underground Investigations – rock conditions and workings extent
- Rock Quality: American Tunnel (Burns Member) cores & rock hardness results
- Secondary permeability index- packer tests in Red and Bonita at the bulkhead location – effectively impermeable / 1.54 x 10^{-14} L/m2
- Overburden elevation at bulkhead site ~ 196 feet
- Hydraulic fracturing and hydraulic jacking/fractures
- Probable head pressures analysis

Mine Elevations/Bulkheads/mine pool elevations

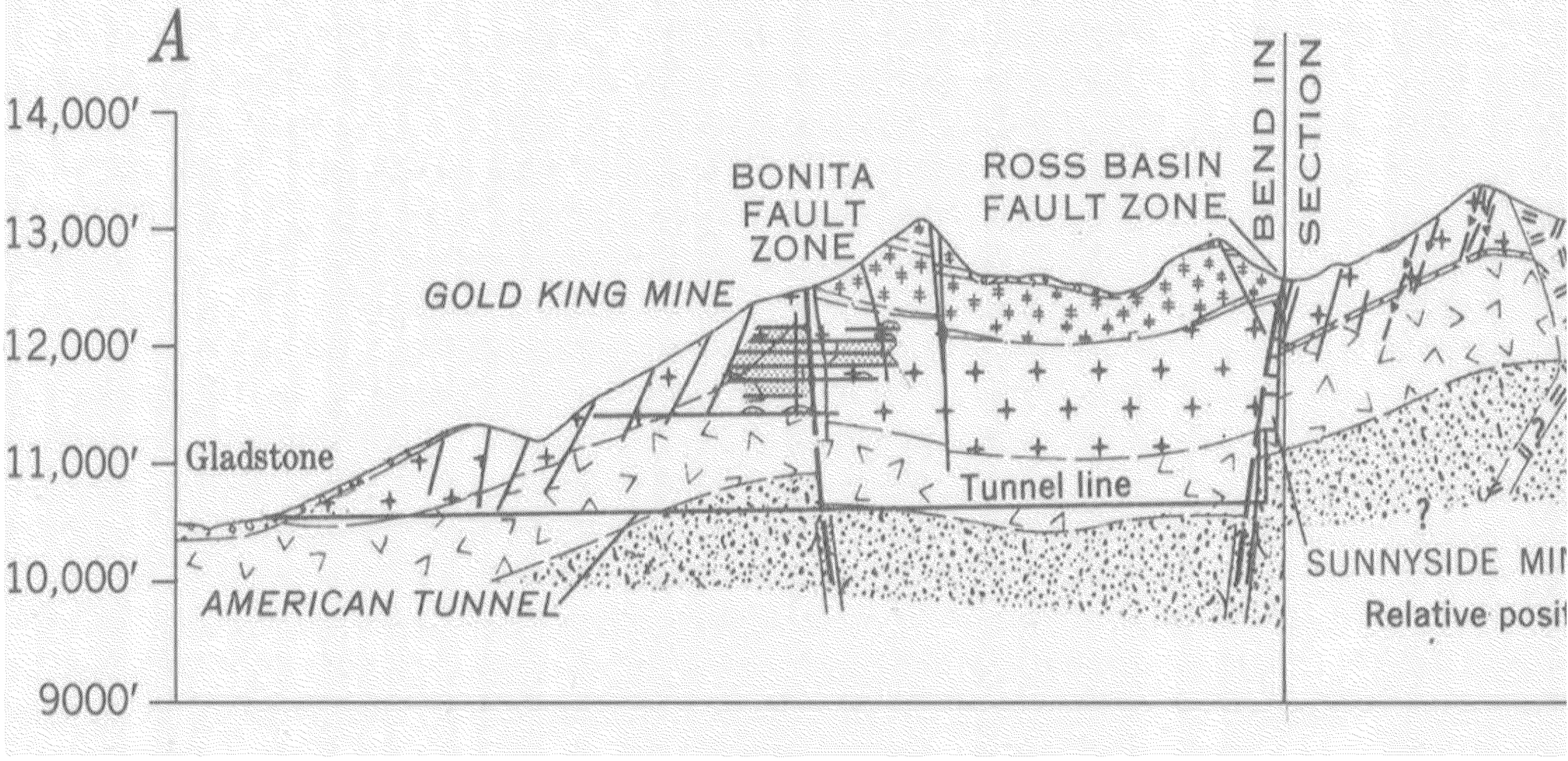
DATE	Mine & Bulkhead Status & Pressure (psi)	Elevations
9/xx/1994 ?	Terry Tunnel Bulkhead #1 – constructed	Portal 11,554 ft
9/9/1996	American Tunnel Bulkhead #1 - closed	Portal 10,660 ft
	Red and Bonita Mine Portal	Portal 10, 957 ft
	Mogul Mine – bulkhead	Portal 11,400 ft
	Gold King Level #7	Portal 11,440 ft
American Tunnel Bulkhead #1 Pressure Gauge		
9/3/1997	312	Mine Pool elev. 11,380 feet
8/28/1998	359	Mine Pool elev. 11,488 feet
9/24/1999	415	Mine Pool elev. 11,618 feet
10/10/2000	440	
12/4/2000	438	Mine Pool elev. 11,671 feet
3/27/2001	438	
5/14/2001	438 Final Pressure	Final Measure 11,671 ft

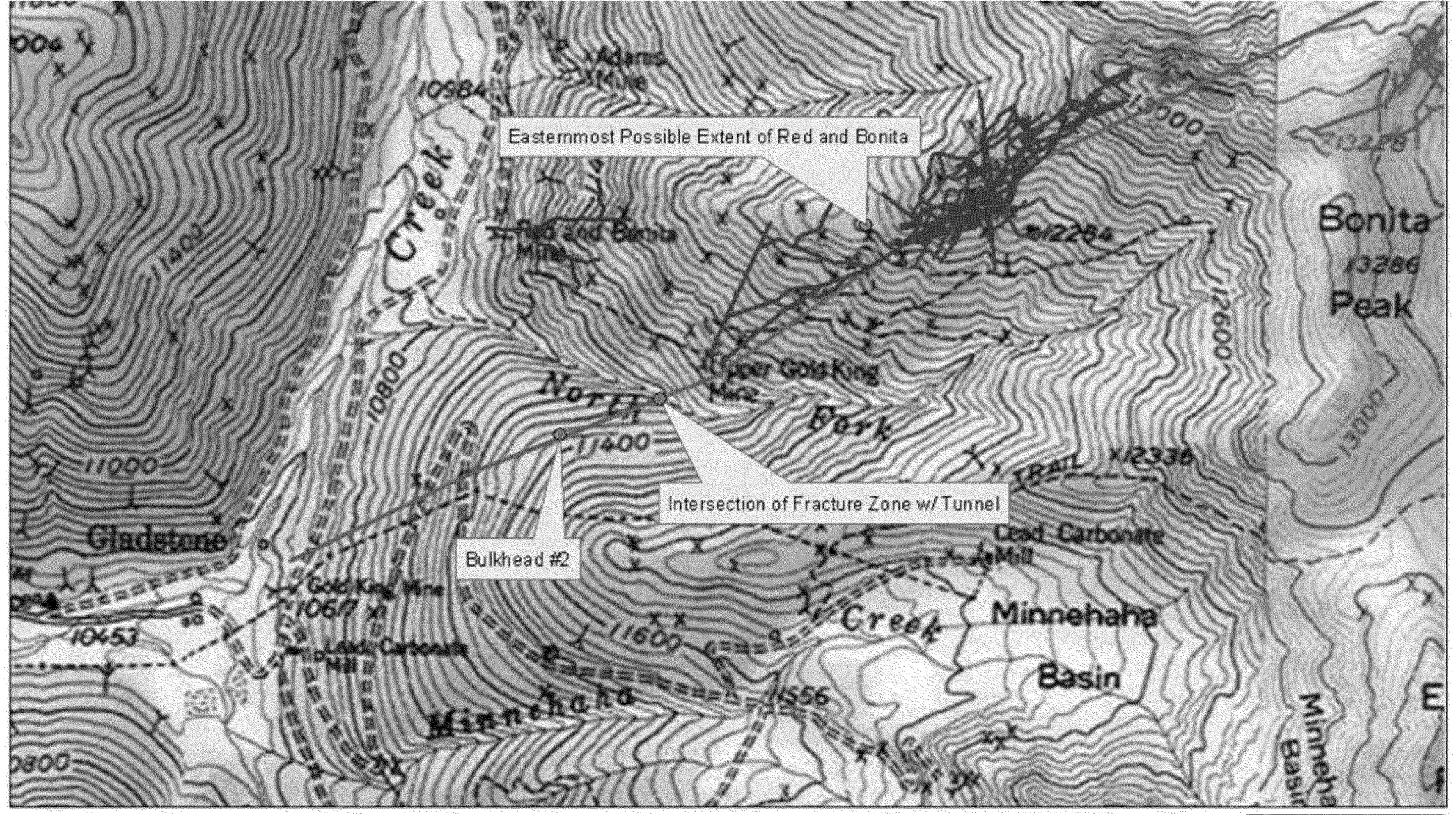
Water Elevations / Pressure Heads / Rock Thickness

Pressure Head	Water Pressure	Required Rock Thickness
1253 feet (Lake Emma)	543 psi	237 feet
714 feet (Sunnyside Mine Pool)	309 psi	135 feet
500 feet (Probable Head)	217 psi	95 feet
1037 feet (hydro-fracing Point)	449 psi	196 feet

Water Elevations and Bulkhead Pressures

- American Tunnel bulkhead #2: constructed for a maximum water head of 640 feet, equating to a water table at 11, 251 feet elevation
- bulkhead #2 pressure equilibrated at 11,015 feet elevation when the water intersected an outlet to surface via the Red and Bonita mine, elevation 10, 957 feet.
- Red and Bonita bulkhead - potentially cause an increase in ground water to the 11, 251 feet, which is the projected Am Tn #2 pressure.
- At 11,251 ft, the pressure head of 294 feet (127 psi) at the Red and Bonita bulkhead.
- The next pathway for ground water to surface would be at the Gold King level #7, 11, 440, which would create a pressure head of 483 feet (209 psi) at the Red and Bonita bulkhead.


A
14,000′
13,000′
12,000′
11,000′
10,000′
9000′
BONITA
FAULT
ZONE
ROSS BASIN
FAULT ZONE
BEND IN
SECTION
GOLD KING MINE
Gladstone
Tunnel line
AMERICAN TUNNEL
SUNNYSIDE MI
Relative posit



Upper Cement Creek

5/14/2015

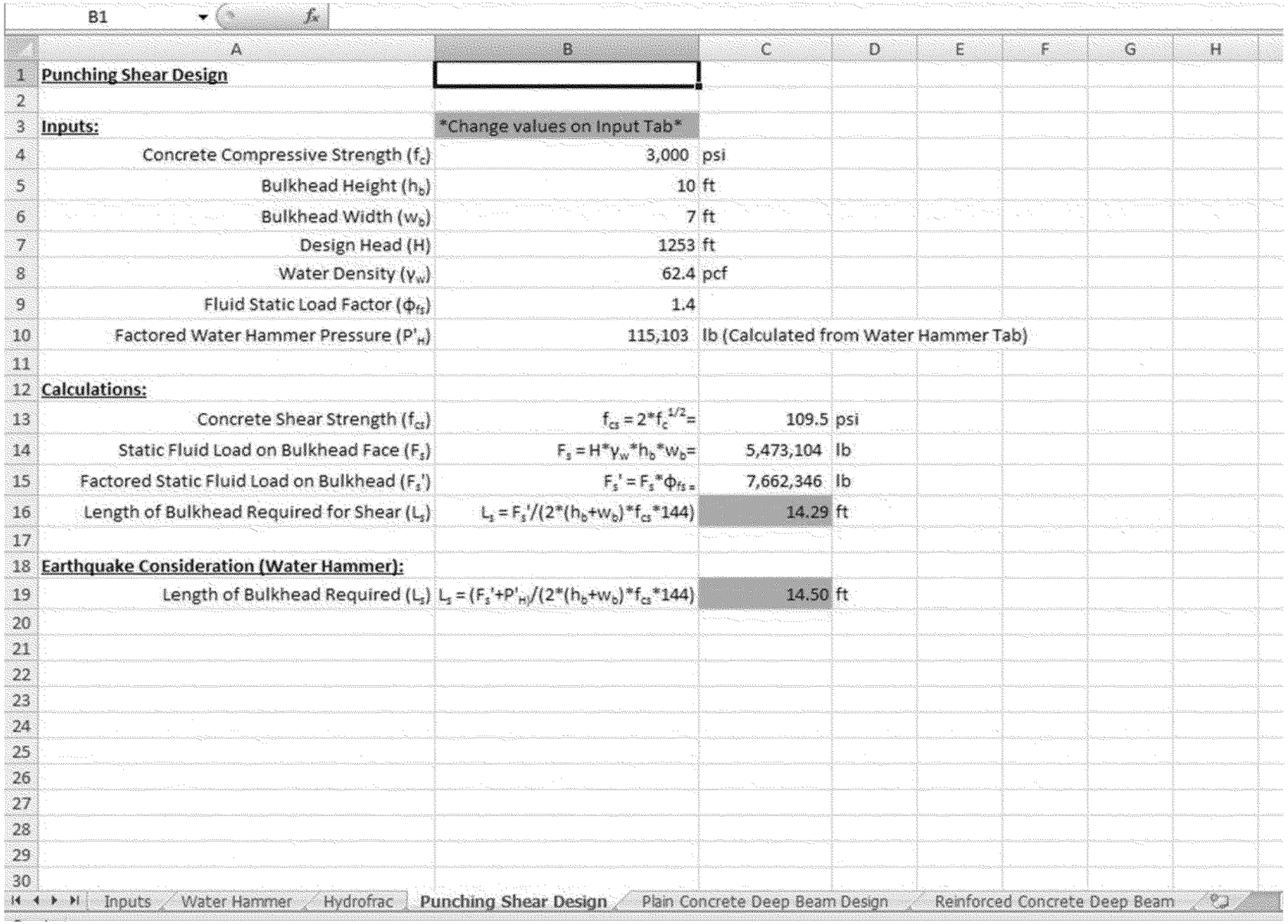
0 0.125 0.25 0.5 0.75 1 Miles

Legend
- Mogul and Grand Mogul
- Red and Bonita
- Gold King
- Sunnyside

Red and Bonita Bulkhead Design Basis – analysis and results

- 6 foot long bulkhead (reinforced) will perform adequately under a pressure head of 500 feet (217 psi), which is Gold King – 7 level plus
- 15 foot long bulkhead (reinforced) will perform adequately under a pressure head of 1253 feet (543 psi), which is the pressure head that would occur on the Red and Bonita mine if the Sunnyside mine pool were to climb to the Lake Emma outlet elevation.
- While this scenario is considered highly unlikely, EPA and CIMRP determined that it is prudent to construct the Red and Bonita bulkhead to this conservative standard. (The cost difference is small.)
- This is true even in the case of a potential Gold King mine bulkhead.
- This design uses the methodologies detailed in Einarson and Abel (1990) and Lang (1999) for maximum hydrostatic head at the bulkhead of 1253 feet and an earthquake acceleration of 0.185 g.

Red and Bonita Bulkhead Design Spreadsheet



	A	B	C	D
1	**Punching Shear Design**			
2				
3	**Inputs:**	*Change values on Input Tab*		
4	Concrete Compressive Strength (f_c)	3,000	psi	
5	Bulkhead Height (h_b)	10	ft	
6	Bulkhead Width (w_b)	7	ft	
7	Design Head (H)	1253	ft	
8	Water Density (γ_w)	62.4	pcf	
9	Fluid Static Load Factor (ϕ_{fs})	1.4		
10	Factored Water Hammer Pressure (P'_H)	115,103	lb (Calculated from Water Hammer Tab)	
11				
12	**Calculations:**			
13	Concrete Shear Strength (f_{cs})	$f_{cs} = 2*f_c^{1/2}$=	109.5	psi
14	Static Fluid Load on Bulkhead Face (F_s)	$F_s = H*\gamma_w*h_b*w_b$=	5,473,104	lb
15	Factored Static Fluid Load on Bulkhead (F_s')	$F_s' = F_s*\phi_{fs}$ =	7,662,346	lb
16	Length of Bulkhead Required for Shear (L_s)	$L_s = F_s'/(2*(h_b+w_b)*f_{cs}*144)$	14.29	ft
17				
18	**Earthquake Consideration (Water Hammer):**			
19	Length of Bulkhead Required (L_s)	$L_s = (F_s'+P'_H)/(2*(h_b+w_b)*f_{cs}*144)$	14.50	ft
20				
21				
22				
23				
24				
25				
26				
27				
28				
29				
30				

Inputs | Water Hammer | Hydrofrac | **Punching Shear Design** | Plain Concrete Deep Beam Design | Reinforced Concrete Deep Beam

Red and Bonita Bulkhead Features and Specifications

- bulkhead dimensions are 6’ x 8’ x 15’ long
- bulkhead volume is 27 cubic yards – this may require adjustment once bulkhead location is scaled and mucked
- low pressure grouting is necessary around the upper contact of the concrete with the roof of the adit
- flexural reinforcing at the bulkhead outby end is #9 bars on 9 inch centers and temperature shrinkage rebar at the bulkhead inby end is #6 bars
- eight inch stainless steel bypass and three-fourth inch monitoring piping will be installed
- Concrete will use sulfate resistant Type V cement, 559 lbs. per cubic yard of concrete and 240 lbs. fly ash, water/cement ratio of 0.52 by weight, and will include Xypex® admixture for waterproofing

LONGITUDINAL CROSS SECTION OF BULKHEAD

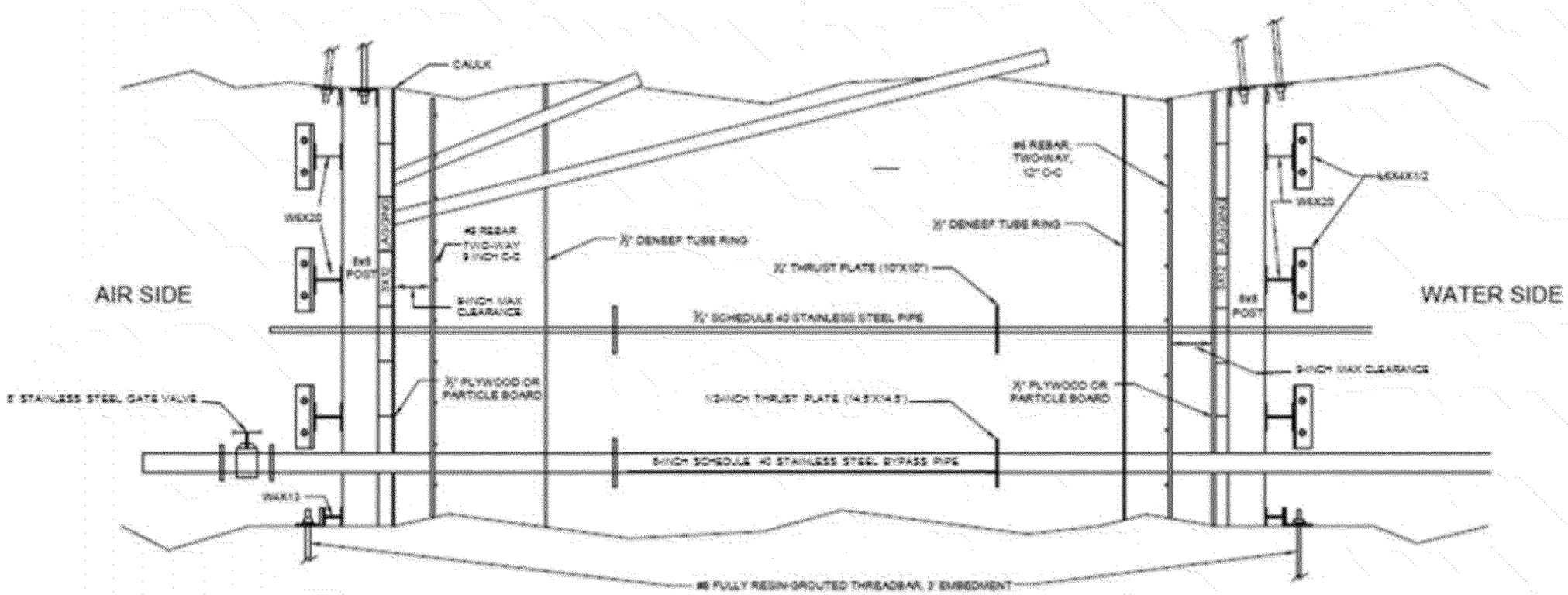


PLATE 1	RED AND BONITA MINE BULKHEAD
SCALE 0 FT — 5 FT	COLORADO Division of Reclamation, Mining and Safety Department of Natural Resources

Monitoring Pressure and Water Flow / Quality

- Pressure Monitoring – transducer and standard pressure gauge
- Bulkhead Sampling Port and Injection Line
- Water Flow and Quality Monitoring
  - Adits: Gold King, Mogul, American Tunnel, Gold Point, Adams and Silver Ledge
  - Surface Water: NFCC, bracket R n B reach CC03 & 03B, CC17 CC18B, CC18, C48, , Eureka Gulch, A72
  - Seeps/surveillance – R n B vicinity
- Visual inspection of the bulkhead and surrounding zone